Physicochemical, rheological & functional differentiation of yam (*Dioscorea* spp.) starches from Nigeria – A key for potential industrial applications

O. Gibert [1], A. Lopez-Montes [2], A. Prades [1], B. Otegbayo [3]

[1]CIRAD, UMR QUALISUD, France; [2]IITA, Nigeria; [3]Bowen University, Nigeria

Introduction

Yam are starchy staples produced by annual and perennial vines grown in Africa, the Americas, the Caribbean, Asia and South Pacific. Despite an African production of about 96% of the world's annual total products of yams (52 Mt in 2007) [1], yam consumption and use in Nigeria is restricted to a narrow range of food products. However, there are hundreds of wild and domesticated *Dioscorea* species known.

In order to investigate the potential industrial use of Nigerian yam starchy resources, with specific quality traits sought by the food industry, this work aimed at characterizing their physicochemical and functional properties.

Material and methods

16 accessions of commonly cultivated yam tubers : (5) *Dioscorea rotundata*, (5) *D. alata*, (5) *D. bulbifera* and (1) *D. dumetorum* were harvested between 6 and 7 month old from yam germplasm of the International Institute of Tropical Agriculture (IITA). Starches were extracted as per Otegbayo et al. 2011[2] and characterized by various physicochemical (DM, soluble sugars by HPAED, amino-acids by HPLC, minerals by ICP-AES) [3-4], rheological and functional means by uniaxial relaxation test and Rapid Visco Analyzer (RVA) profile using a rheometer.

The pasting properties of starch were measured using the RVA starch cell on a MCR301 rheometer with a 8% db starch concentration at 95°C under constant stirring at 160rpm, whereas the relaxation test was carried out on a 15mm height pulp cylinders (raw and cooked 20 min.) at 20% strain for 60s using a TaXTPlus texture analyzer (SMS, UK). Starch granule size was also characterized using a Mastersizer (Malvern, UK). Principal Component Analysis was performed on most important variables using Statistica software (Statsoft, US).

Results and discussion

Fresh pulp dry matter content helped to discriminate *rotundata* (***R*** 34.6%) from *dumetorum* (***D*** 28.2%), *alata* (***A*** 27.6%), and *bulbifera* (***B*** 26.7%) species without strong correlation being shown with the fresh tuber specific gravity (**Fig 1**). However, as expected the most appreciated varieties (R&A) exhibited higher dry matter content and specific gravity than those of the neglected ones (***B*** & ***D***). It suggests some compositional differences among species.

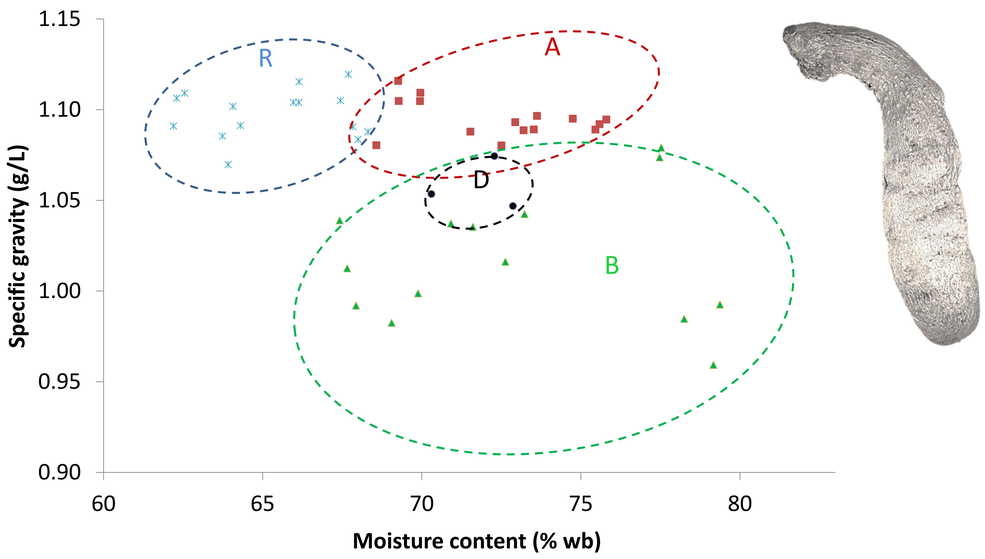

Fig 1. Specific gravities vs moisture contents of yam tuber species pulps

Principal component analysis showed 3 main axes. The first one is mainly linked to some minerals (Ca and K) and sorbitol content, the second one to starch phosphorus content, moisture content of the pulps and glucose content, whereas the third one mainly to total amino acids and starch content. A hierarchical cluster analysis evidenced 3 groups as illustrated in Figure 2 loadings with species of *D. Rotundata* linked to *D. Dumetorum*, and *D. Bulbifera* and *D. Alata* well-differentiated.

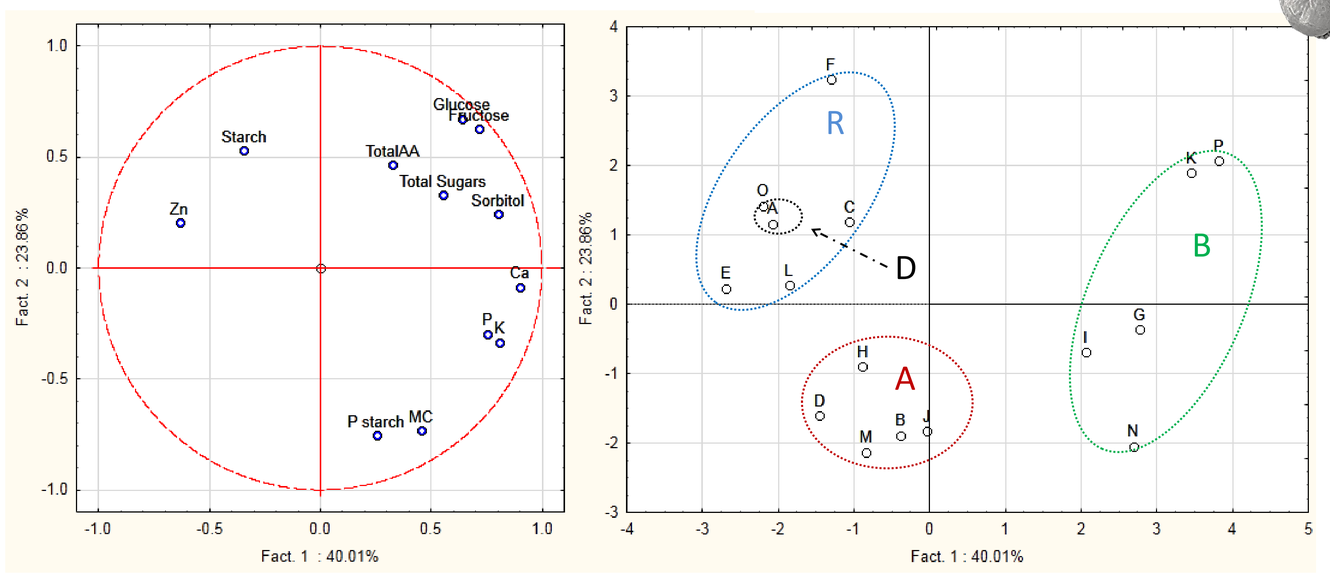

Fig 2. Scores and loadings on the first two axes of the PCA

Complementary analysis of the relaxation properties (Fig. 3) before and after cooking highlighted various relaxation work and ratio of initial to final relaxation force (F2/F1) as illustrated in Table 2. If *D. Dumetorum* exhibited the highest work of relaxation, *D. Bulbifera* exhibited a similar work to those of the other species.

Table 2. Relaxation properties of the raw and cooked varieties

Species	Work (g.mm)	F2/F1
D. Alata (16)	*18717±3084* ***A***	*0.629±0.024* ***A***
	1074±668 ***a***	*0.450±0.071* ***a***
D. Bulbifera (24)	*12269±3356* ***BC***	*0.583±0.023* ***B***
	1369±648 ***a***	*0.288±0.042* ***b***
D. Dumetorum (3)	*11182±6548* ***B***	*0.546±0.019* ***C***
	2776±667 ***b***	*0.347±0.117* ***b***
D. Rotundata (26)	*17029±5384* ***AC***	*0.614±0.020* ***A***
	1968±656 ***ab***	*0.471±0.055* ***a***

(number of measurements in brackets)

(**) Means followed by the same capital (raw tuber) and small (cooked tuber) letters in the same column are not significantly different (p≤0.01)

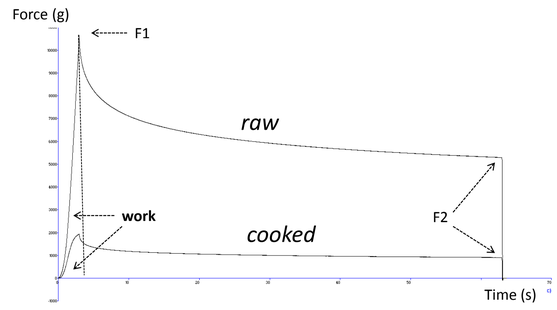

Fig 3. Relaxation profile of *D. Dumetorum*

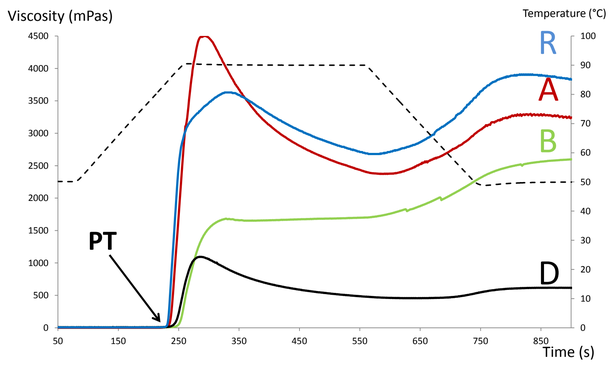

Fig 4. Illustration of the RVA pasting profiles

Large variation in pasting properties (**Fig. 4**) were observed among species. *D. Alata and D. Rotundata* exhibited high peak viscosities (with a similar granule size about 29µm) and high shear sensibility, whereas *D. Bulbifera* did not display any peak with a good shear resistance with a significant increase in viscosity on cooling. Contrary to the other species, *D. Dumetorum* exhibited low paste viscosity with small granule size (3µm), moderate shear resistance with limited viscosity increase on cooling. Both *D. Dumetorum* and *D. Bulbifera* exhibited the highest pasting temperatures (PT).

Conclusion

Dioscorea starches displayed a quite large diversity and had indeed clearly different physicochemical and functional properties. They exhibited various relaxation profiles, thermal resistance (pasting temperature) and shear resistance. In particular, *D. Dumetorum* and D. *Bulbifera* thus appears to be a promising source of starch diversity with a potential expansion and utilization to a narrow range of food industrial products.

References

1 Yam crop – IITA. http://www.iita.org/yam (online 11/2012)

2 Otegbayo B, Gibert O, Lopez-Montes A, Ricci J, Dufour D. Physicochemical and rheological characterization of yam starch for industrial potentials. 23-28 September 2012. *In* 16th International Symposium of the International Society for Tuber & Root Crops (ISTRC) on Root Crops.

3 Gibert O, Dufour D, Giraldo A, Sánchez T, Reynes M, Pain JP, González A, Fernández A, Díaz A. Differentiation between cooking bananas and dessert bananas. 1. Morphological and Compositional characterization of cultivated Colombian Musaceae *(Musa* sp.) in relation to consumer preferences. Journal of Agricultural and Food Chemistry, 57(17), 7857-7869, (2009). *Err.* 58, 9290 (2010).

4 Total amino acids in vegetables. Std Operating Procedure for Biochemical and nutritional analysis for Group 3 (Nutri-ExtPlantes-04-fr & Nuri-Cere-002-fr), *FP7 AFTER project* .

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